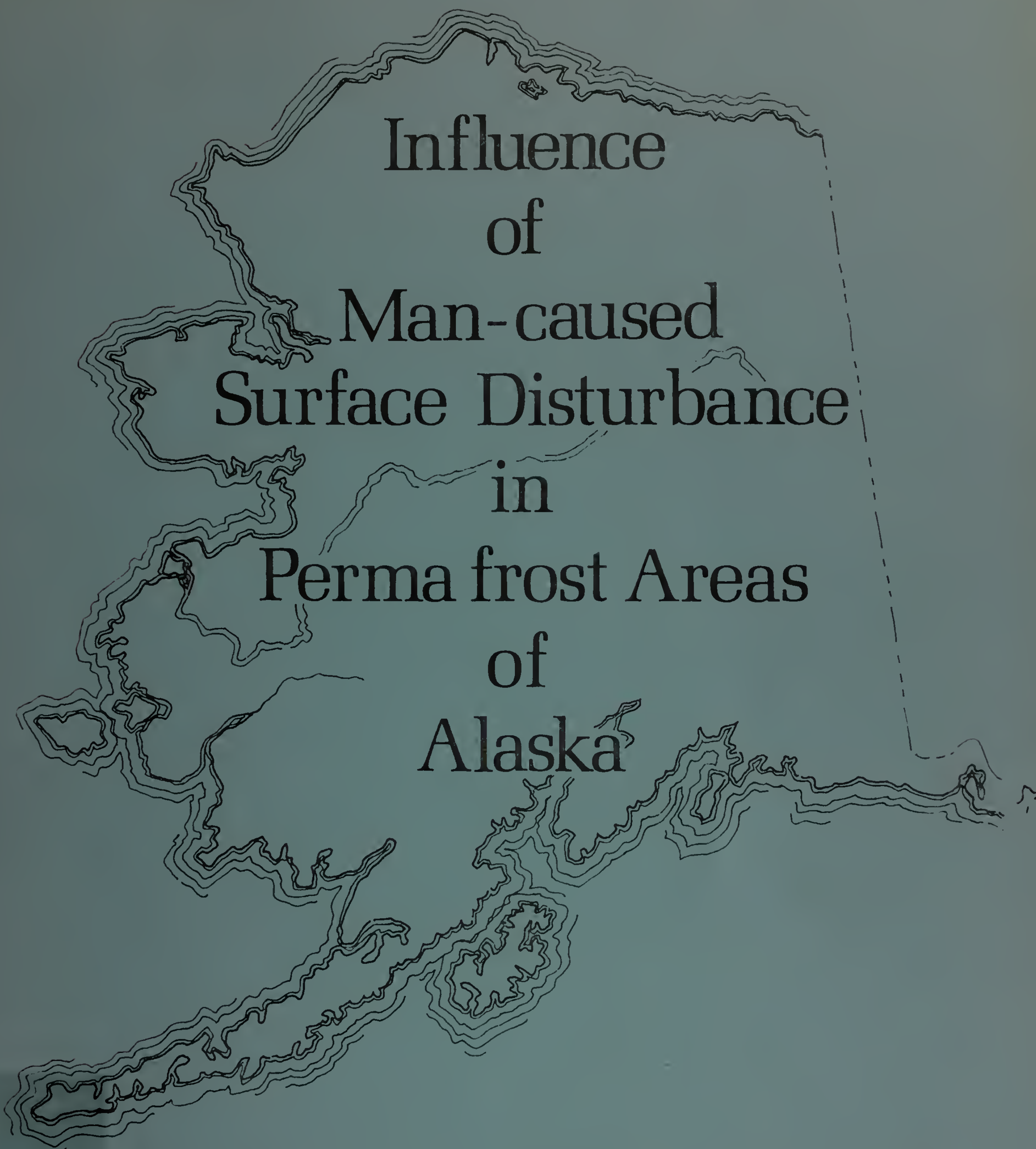
Influence of Man-caused Surface Disturbance in Perma frost Areas of Alaska



Report of Special Committee Assigned by State Director of Alaska
1973

U. S. Department of the Interior
Bureau of Land Management

INFLUENCE OF MAN-CAUSED SURFACE DISTURBANCE IN PERMAFROST AREAS OF ALASKA

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Robert D. Martin
Chairman

Salvatore De Leonardis

Roger Bolstad

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ABSTRACT

The State Director of Alaska organized a study team to report on problems resulting from man-caused surface disturbance in permafrost areas of Alaska.

Most surface disturbance is caused by vehicles which are operated off surfaced roads. Such vehicle use is included in activities like seismograph exploration, mining, recreation, and control of wildfires.

Surface disturbance resulting in destruction of vegetation or tearing of the surface organic mat is followed by thawing of permafrost. This often results in surface subsidence, soil erosion, and siltation. These reduce water quality, aesthetic values, and access.

Methods are recommended to minimize surface disturbance through improved procedures for control of wildfires and application of regulations for off-road vehicle use. Also recommended are methods to control effects of surface disturbance by thermal insulation, revegetation, and drainage control structures.

The primary objective in land management of permafrost areas should be to prevent accelerated soil erosion through the following guidelines:

> Identify thaw-unstable permafrost areas and zone them for strict management control to prevent or minimize surface disturbance; zone other areas for development and resource use with management control of surface disturbance; and rehabilitate all areas that are damaged.

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1. Introduction

Often man-caused surface disturbance in permafrost areas of Alaska has reduced land use and resource values because of the induced thawing. Resource managers are becoming more aware of this and recognize the need to protect against resource damage from permafrost thaws. The State Director of Alaska organized a team to review the problem and suggest management guidelines for permafrost areas in Alaska.

Permafrost conditions may occur in all types of material. Permafrost varies in depth and extends to hundreds of feet in high latitudes. The zone overlying permafrost that yearly freezes and thaws is called the active layer. It is of variable depth from a few inches to several feet.

Permafrost temperatures vary. Moisture content and ice segregation of permafrost also vary. Consequently, large volumes of ice occur in some areas. Massive ice occurs at variable depths and may be covered by many materials, including peat and silts. Silty ice-rich soils become unstable during thawing. Surface disturbance that damages the organic mat results in thawing of the subsurface materials. Surface subsidence follows melting of subsurface ice. The silty material erodes easily and is carried downslope and often into streams.

This report considers these permafrost conditions and suggests guidelines for land management goals in permafrost areas and includes recommendations to fire control personnel for selecting routes and techniques for fireline construction.

II. Identification of permafrost occurrences

There are three regions of permafrost: continuous, discontinuous, and sporadic. In the continuous region permafrost underlies all types of terrain, with the probable exception of large rivers and deep lakes. In the discontinuous and sporadic regions permafrost is isolated, and its occurrence is difficult to predict.

The occurrence of permafrost depends upon the glacial and climatic history, thermal properties of the surface and subsurface materials, and the annual energy transfer at the ground surface.

A. Permafrost is more likely to be present in the following areas:
   1. Alpine tundra.
   2. North-facing slopes.
   3. Poorly drained and swampy areas.
   4. Areas with a thick layer of moss or peat.

B. Indicators of permafrost include:
   1. Patterned ground like frost polygons.
   2. Thin stands of black spruce and tundra.
   3. Taiga forests.

C. Areas where permafrost is less likely to occur:
   1. South-facing slopes.
   2. Flood plains along rivers.
   3. Well drained soils.
   4. Areas with larger trees.

III. Causes of surface disturbances and effects on permafrost

Surface disturbance is the effect of man's activities on vegetation and the surface organic mat. Disturbance may vary from the effects of one passage of a vehicle to removal of the organic mat. The single passage of a vehicle may result in no damage or only slight compaction of the organic mat. But one pass of a vehicle over an area may cause sufficient compaction of the organic mat to upset the thermal balance and cause the permafrost to start thawing. Subsidence and soil erosion may follow. More severe disturbance causes minor or major tearing of the organic mat. Complete removal of the organic mat, such as for fireline construction, is extreme disturbance, and subsequent erosion often is serious.

Factors which influence the effect of surface disturbance include climate, soil properties and erodibility, physiography, ice content and temperature of the permafrost, and the degree of surface disturbance.

A. Causes. Nearly all of man's activities in permafrost areas induce changes in the conditions of the ground surface. This report considers activities that cause the most significant ground surface disturbances.

1. Off-road vehicles (ORV's) used for government, business, or recreational activities have a major influence in permafrost areas. The types of ORV's employed in Alaska vary in design and have a wide potential for causing surface disturbance. Vehicles may be commercially manufactured (including regular passenger sedans) or homemade, and they may have standard tires, tires with chains, wide tires,

tire and track combinations, or tracks only. Surface loading is from less than 0.5 to over 40 pounds per square inch (psi). Steering systems range from skid-type to center-frame, joint-articulated system. Vehicles designed to produce low average ground pressures of 3.5 psi or less may be acceptable for use over permafrost terrain. Little surface compaction or damage has been caused by such low pressure vehicles under specific tested conditions. However, even these vehicles, when improperly operated, tear the surface organic mat.

2. Wildfire control activities. Over 80% of interior Alaska has been burned or reburned by wildfires. An annual average of 824,000 acres has burned the last 17 years. Field observations of areas with burned organic layer and melting permafrost show some slumps and slides occurring.

Firelines must be cleared to mineral soil to be effective. If this clearing is done in permafrost areas, it will cause rapid thawing, and in ice-rich silty soils, subsidence and erosion also occur. Bulldozers are used to construct approximately 80-100 miles of fireline each year. Much of this could be in permafrost areas.

3. Recreation activities involving the use of off-road vehicles (ORV's) result in surface disturbance. Repeated ORV traffic over a route causes compaction and tearing of the organic layer. This may expose the mineral soil and cause erosion. Ice-rich silty soils are particularly unstable when thawed. Serious damage occurs from use of ORV's during thawing and freezing seasons.

Even compaction of the surface vegetative cover can lead to thawing, subsidence, and erosion. Snow machine traffic may cause sufficient compaction to result in permafrost thawing and erosion the following summer.

4. Mining activities also cause melting of permafrost and subsequent erosion. Exploration trails, excavations, and placer mining methods cause surface disturbance.

5. Seismograph exploration is usually a ground based operation. The use of ground equipment causes surface disturbance. Clearing areas for placement of explosives results in some surface disturbance.

6. Rights-of-way development. Right-of-way exploration and construction activities cause surface disturbance through compaction or removal of the organic layer.

7. Surveying activities. Much of the cadastral surveying in Alaska is done with helicopters. ORV use for surveying is restricted mostly to areas with access. In these areas there is evidence of damage from the use of ORV's for surveying.

8. Other.

(a) A limited amount of timber harvesting is done in areas of discontinuous permafrost, and this may cause surface disturbance and erosion.

(b) Farm clearing causes surface disturbance.

(c) Military personnel and equipment activities often cause surface disturbance and permafrost melting.

B. Effects. Surface disturbance in permafrost areas increases the active layer. If there is a foreknowledge of the effect of a disturbance and of information on the ice content of the permafrost, it is possible to predict the amount of subsidence and relief changes that will result. (Mackay, 1970). When the permafrost is gravelly or sandy, water and ice content is generally low. Compaction or removal of the surface vegetation may cause thawing, but these materials remain stable, and even on steeper slopes there may be little erosion. Thawing of permafrost should not be considered damage in all cases. Thawing may be beneficial from the standpoint of human use and development, e.g., agricultural development. Thawing of permafrost can be considered damaging only when the results are detrimental to resources or resource use.

The effects of permafrost thawing on the environment are:

1. Soil erosion. After the surface is disturbed, thawing, ponds, small streams, soil flowage, and erosion can develop. When the area serves for collection of surface runoff, massive erosion can occur. If the slope is sufficient, slumps and slides also occur.

When the organic layer is removed from ice-rich permafrost, rapid thawing follows. Gullies can develop by headcutting and this erosion causes siltation of land and water.

Slumps and soil erosion also can develop after vegetation burns. Soil movement occurs as the permafrost thaws. Not all gullies or ruts form from soil movement downslope. Subsidence forms gullies by thermal erosion.

2. Decreased water quality. Thawing of permafrost affects water quality when eroded material from the area enters a water body.

Tractor-constructed firelines that intersect streams cause decreased water quality. These firelines channel water and cause erosion and siltation. They also carry into streams the materials released by the fire and thawing permafrost.

3. Lower aesthetic values. Surface disturbance in permafrost areas usually has an adverse impact on scenic values. Disturbance and thawing of permafrost may result in severe and long-lasting visual effects. Differential subsidence, erosion, gully formation, and the loss of surface vegetation can leave conspicuous effects. All are long-lasting, visible results of the disturbance. Distrubance by vehicular traffic is often in long straight lines and appears highly artificial in a natural setting.

Vehicle traffic on tundra does not always result in melting of permafrost. Repeated passage over tundra leaves a visible mark on the landscape, even though the organic layer remains intact and no permafrost melts. In some cases a single passage has been sufficient disturbance to leave a visible mark. These types of trails often are difficult to detect on the ground, but may be highly visible from the air.

4. Reduced access. Gullies and mudflows can damage existing roads and trails as permafrost thaws and erosion occurs.

It is common to locate new trails adjacent to unusable trails. The relocated trail often becomes impassable, too. This results in a series of parallel trails across the terrain. Vehicle or foot travel across these trails may be difficult.

IV. Methods to minimize surface disturbance

Vehicular use is the primary cause of surface disturbance in permafrost areas. This disturbance promotes thawing of the underlying permafrost and may result in accelerated erosion and other environmentally undesirable effects.

Recommendations to manage vehicular use and minimize surface disturbance follow.

A. Improved procedures for control of wildfire. Fire control activities, particularly dozer-constructed firelines, have caused significant thawing of permafrost. The use of dozers has been convenient on large fires within approximately 25 miles of existing roads. As the road system is expanded, use of dozers for fireline construction will expand also. Alternatives to conventional dozer use should be considered to reduce possible surface disturbances. Such alternatives include:

1. Quick detection and action on fires would reduce the need for dozer-constructed firelines.

2. Use of penetrating retardant instead of clearing a line to mineral soil. Other chemical techniques should be evaluated.

3. Develop equipment capable of constructing firelines narrower than conventional dozer firelines.

4. Develop systems of roads, trails, and firebreaks in critical protection areas to act as preconstructed firelines.

5. Train fireline supervisors to identify problem areas. Refresher briefings should be given overhead teams before they are dispatched to fires.

The Wickersham Dome fire could be analyzed and used for a training model. The burn area was covered with good aerial photography. Fireline construction could be analyzed to see where the lines could have been made to minimize the problems from thawing permafrost and yet achieve fire control objectives. This area has had some rehabilitation effort which could be considered in the training.

Watershed specialists should assist plans chiefs in preplanning fireline location to minimize problems from melting permafrost. The watershed specialists could train fire overhead on permafrost identification and melting problems. Also, the watershed specialists could plan rehabilitation of the disturbed areas.

The following are recommendations for fireline design and construction in permafrost areas:

1. Avoid building firelines in ice-rich permafrost areas such as north slopes or drainage bottoms where the organic mat is more than 12 inches deep. Dry ridge tops and south slopes are preferred over other areas for fireline construction.

2. Avoid building firelines on gradients sufficient for inducing erosion. Generally build firelines on contours and add lateral drainage to side slopes into undisturbed areas.

3. Use rivers as lines where possible. If it is necessary to build lines along rivers, locate lines along uphill side of some better drained soils, e.g., where white spruce stands occur.

4. Avoid creating an erosion "chute" into natural drainageways, e.g., the firelines should have a dogleg or be stopped 300 feet from drainages, rivers, or lake shores.

5. Fireline width must be controlled. An adequate fireline is a walked-down portion as wide as the height of the tallest tree and a minimum width cut to mineral soil.

6. Tracked equipment should be operated only on established lines, preferably on the "walked-down" portion.

7. Construct cross-drainage approximately every 50 yards to direct water into undisturbed areas. Construction of cross drainage should be an integral part of the fireline construction.

B. Regulation of off-road vehicle use. Disturbance may result from frequent ORV use in permafrost areas. Time and space zoning may be necessary in areas of heavy demand. Zoning plans should consider priorities for ORV access, type of vehicles to be allowed, the value of designated trails, the tolerable uselevel, and the optimum time of year to reduce disturbance. Demand use areas would require designating trails for use.

In order to meet public demand for different types of hunting recreation, the Alaska Department of Fish and Game has established several controlled access areas. These were located in areas of intense hunter use to provide quality control in hunting rather than prevent soil disturbance. The areas are generally closed to all motorized vehicular traffic involving hunting or transporting game, and in some areas pack animal use also is restricted. The concept is not completely functional because the nonhunting ORV user cannot be excluded except on State land. Coordinated State-Federal activities would help solve zoning problems. Along with zoning, other limitations for ORV would be necessary. For example, studies have demonstrated that the surface pressure a vehicle exerts should be less than 3.5 psi to reduce surface disturbance. Other factors to consider include steering system, track surface or shape, number of passes, vehicle maneuvering, and soil conditions. Restrictions in ORV use should apply to government as well as private activities.

V. <u>Methods to control effects of surface disturbance</u>. Rehabilitation should be planned and implemented for disturbed areas. When the organic layer is disturbed or removed from ice-rich areas, it is important to start rehabilitation as soon as possible. The following rehabilitation steps are recommended for permafrost areas disturbed by activities such as control of wildfires:

A. <u>Drainage control structures</u>. Water should be prevented from accumulating because water increases the thawing rate of the permafrost.

1. Backfilling and water bar construction should be accomplished using line building equipment prior to its release from the fire project.

2. Construct water bars across firelines with organic surface material. Use either mineral soil or the organic material for building water bars and space at 30-50 yard intervals on gentle slopes. The water bars should be spaced closer on steeper slopes. Nearly level firelines along contours require fewer water bars, yet water always should be diverted from the firelines. Mineral material is necessary on the uphill side of the berm to seal it against water percolation. Bars should be angled to slope less than 2% and high enough to divert runoff into undisturbed areas.

3. Drainage control structures should be completed as soon as possible after the fireline construction and prior to severe permafrost melt. Permafrost thawing starts immediately after the organic mat is removed.

B. Revegetation.

1. Seed the disturbed surfaces immediately after the disturbance. The goal is to quickly establish a vegetative cover to prevent erosion and protect the underlying permafrost.

2. Recommended species and varieties for seeding include Durar hard fescue, Arctared red fescue, meadow foxtail, and Nugget Kentucky bluegrass. Cereals can be used for quick cover. Illinois redtop should be considered for the North Slope. Polar bromegrass and Engmo timothy should be considered for other critical areas.

3. Seeding rates should be about 15 to 35 pounds of seed per acre. If cereal grains are included, the rate should be increased 35 to 50 pounds per acre.

4. Fertilizer is necessary to establish satisfactory grass stands. At the time of seeding, fertilizer should be applied to supply 50 to 60 pounds of nitrogen per acre and 60 to 70 pounds of phosphorus per acre, e.g., 350 pounds 18-46-0 per acre. The following year where necessary to maintain a plant cover there should be a second application of about 20 pounds of nitrogen and 30 pounds of phosphorus per acre.

5. Transplanting of brush and trees for erosion control and screening is desirable for some sites.

6. Use aerial methods to apply fertilizer rather than on-the-ground treatment methods.

C. Thermal insulation. Where small restricted problem areas have developed, artificial insulation, e.g., excelsior blankets, wood chips, slash, sawdust or styrofoam may be used to retard or stop the permafrost thawing.

VI. Land management objectives in permafrost areas

The primary objective should be wise and conservative use of available resources while avoiding soil erosion or subsidence.

Resource management objectives in permafrost areas could be based on one of the following alternatives:

A. Prevention of surface disturbance in permafrost areas.

B. Allow resource use in permafrost areas without restrictions and depend upon conventional methods for rehabilitating damaged areas.

C. Zone permafrost areas where objectives in some areas would be for Alternative A and in others for Alternative B.

D. Identify thaw-unstable permafrost areas and zone them for strict management control to prevent or minimize surface disturbance; zone other areas for development and resource use with management control of surface disturbance; and rehabilitate all areas that are damaged.

Some advantages and disadvantages for each of the above alternatives are:

A. <u>Prevention of surface disturbance in permafrost areas</u>.

1. Advantages

(a) No disturbance, therefore no accelerated erosion.

(b) Best aesthetics by preservation of natural characteristics.

(c) This alternative would best meet requirements of the National Environmental Policy Act.

2. Disadvantages

(a) Limited alternatives for firefighting.

(b) Restrictions on all development.

(c) There would be limited resource use, probably only restricted recreational use would be allowed.

(d) There would be limited access available.

B. Allow resource use in permafrost areas without restrictions and depend upon conventional methods for rehabilitating damaged areas.

1. Advantages

(a) Unlimited development opportunities.

(b) High degree of fire control.

(c) High recreation use and unrestricted access.

(d) No restriction on resource utilization.

(e) Least overhead cost.

2. Disadvantages

(a) Heavy impact on aesthetics.

(b) Accelerated erosion.

(c) More pollution of streams.

(d) Lowered fishing production because of siltation and increased turbidity of some streams.

(e) Radical changes in the ecosystem.

(f) Some areas where rehabilitation will not succeed and rehabilitation costs will be high.

(g) This alternative conflicts with National Environmental Policy Act.

C. Zone permafrost areas where objectives in some areas would be for Alternative A above and in others for Alternative B.

1. Advantages

    (a) Identifies very critical areas.

    (b) All advantages of both Alternatives A and B.

2. Disadvantages

    Combination of disadvantages of Alternatives A and B.

D. Identify thaw-unstable permafrost areas and zone them for strict management control to prevent or minimize surface disturbance; zone other areas for development and resource use with management control of surface disturbance; and rehabilitate all areas that are damaged.

1. Advantages

    (a) Identifies critical areas on zone map.

    (b) A high degree of protection against erosion.

    (c) Freedom to design an effective fire control program.

    (d) Allows prescribed use of fire or other management techniques.

    (e) Allows for resource development under controls.

    (f) Allows design of projects to meet the National Environmental Policy Act requirements.

2. Disadvantages

    (a) Requires more manpower and funding than other alternatives.

    (b) Needs studies to define impacts of resource use in permafrost areas.

(c) Requires an intensive effort for training and education of resource managers as well as general public.

(d) Research will be needed for new line building or firefighting techniques for fire control of zoned areas.

(e) Soil surveys or other methods for zoning permafrost areas may be needed.

The recommended management objective is Alternative D. It has the greatest option for the land manager and provides for resource protection.

Implementation of the objectives should be through the Bureau of Land Management planning process. The following policies should be used as guidance within the BLM planning system:

1. Land Management should be directed to prevent damage by strict control of all resource uses in critical permafrost areas, i.e., permafrost areas of fine soils with high ice content.

2. The remaining areas of public land would be subject to resource use and development under restrictions necessary to control or prevent surface disturbance and minimize erosion.

3. All disturbed areas should be rehabilitated.

To implement the objectives, the following land management techniques are suggested.

1. Consideration should be made of time and space zoning to control ORV use. This would depend on the soil erodibility and how the erodibility varies with surface disturbance at different times of the year. The objective would be to minimize disturbance of the protective vegetative layer.

2. ORV trails should be designated and posted. South slopes, ridge tops, contours, etc., generally should be used for trails.

3. Impose maximum limitation on ORV ground pressure for use in critical permafrost areas. It may be necessary to establish different criteria to cover different areas, or have a general ground pressure limitation in all areas. Size and shape of track grousers should also be designated. Explore cooperatively with the State of Alaska the possibility of legislation to limit size, weight, and ground pressure of ORV and snowmobiles for overland use.

4. Restrict repeated passes over the same trail, e.g., allow only one pass per trail off designated roads and trails in alpine and tundra areas.

5. Prepare contingency plans for erosion control. For example, water bars at specified intervals on sloping ground, acceptable seed and plants and fertilizer grade and application rates.

Even in the absence of a Management Framework Plan other actions should be considered. Examples of these are:

1. Continue development and use of new fire control techniques. These are needed to eliminate or reduce surface disturbance and the use of crawler tractors in building firelines through permafrost areas.

2. Continue development of rehabilitation techniques. Implement rehabilitation where it is needed.

3. Develop and implement training to assist fire control personnel and land managers to identify problem areas and the techniques that are available to manage these areas.

4. Develop information and education techniques for making the general public aware of the existing problem. Example techniques include working with schools, developing brochures, and using public information media. These techniques should be implemented as they are developed.

5. Adequately support the land management objective. Manpower requirements will increase as land management programs become more intensive.

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